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APPLICATION OF QUADRIPARTITIONED NEUTROSOPH α- LEVEL SETS ON DECISION MAKING PROBLEMS USING MATLAB

R. DAS[1*], P. BAL[1], S. PRAMANIK[2], F. SMARANDACHE[3], K. BHATTACHARJEE[1]

[1]Department of Mathematics, The ICFAI University Tripura, INDIA.
[2]Department of Mathematics, Nandalal Ghosh, B. T. College, Narayanpur, West Bengal, INDIA.
[3]Department of Mathematics, University of New Mexico, 705 Gurley Avenue, NM 87301, USA.
*Corresponding author. E-mail: rakhaldas95@gmail.com

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Summary. In this article, we have introduced a notion of α-level Quadripartitioned Neutrosophic Sets (QNSs). We have applied them in decisionmaking problems. Using the Mathe Lab programming, we solve a job selection decision-making problem. We have established a MatLab programming for the decision-making problem using the QNS. We have established various properties of α-level quadripartitioned neutrosophic sets. This process can be used in various fields of science and technology.

1 INTRODUCTION

Neutrosophic Set (NS) [1] that generalizes both Intuitionistic Fuzzy Set (IFS) [2] and the conventional notion of Fuzzy Set (FS) [3]. Iranian-American mathematician and computer scientist Lotfi A. Zadeh developed the idea of a Fuzzy Set [4] in 1965. K.T. Atanassov finally developed the idea of an IFS [2] in the early 1980s. The NS [1] was subsequently introduced in 1998 by Romanian mathematician and researcher Florentin Smarandache. Fuzzy and conventional logic are both extensions of neutrosophic logic. Application and theoretical development of NS were developed in the studies [5]. Following that, several researchers worked on it and applied the idea to numerous branches of science and technology. Scientific advancements today provide us with a variety of opportunities, but they also cause perplexity. This essay will assist us in removing ambiguity and confusion.

A Quadripartitioned Neutrosophic Set (QNS) is a mathematical concept that extends the notion of a neutrosophic set. Neutrosophy is a branch of philosophy developed by Florentin Smarandache in the 1990s, which deals with the study of indeterminacy, contradictions, and the neutralities existing between various concepts. Neutrosophic sets allow for the representation of uncertain or indeterminate information by considering three components: the truth membership, the indeterminacy membership, and the falsity membership.

The concept of a Quadripartitioned Neutrosoph Set builds upon the indeterminacy component in the neutrosophic set. It is divided into two parts namely “Contradiction” (both true and false) and “Unknown” (neither true nor false) we get four components that are T, C, U, F which define a new set called “Quadripartitioned Single valued neutrosophic set” (QSVNS) introduced by Rajashi Chatterjee., et al. [6] And this is completely based on Belnap's four valued logic and Smarandache's “Four Numerical valued neutrosophic logic”.

The memberships of a Quadripartitioned Neutrosoph Set are real numbers in the interval [0,1], where 0 represents the absence of membership and 1 represents complete membership.

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The sum of the four memberships for a given element should be less than or equal to 1 , indicating that an element cannot simultaneously belong completely to all four components.

QNSs provide a flexible framework for dealing with complex and uncertain information in various fields such as decision-making, expert systems, pattern recognition, and data mining. They allow for a more nuanced representation of information by explicitly considering the neutrality aspect, which is often neglected in traditional set-theoretic approaches.

The operations on QNSs include union, intersection, complement, and subset operations, which are defined based on the individual memberships of the components. These operations enable the manipulation and analysis of QNSs, facilitating reasoning and decision-making in uncertain and contradictory situations.

Applications of Quadripartitioned Neutrosoph Sets can be found in diverse domains, including medical diagnosis, image processing, sentiment analysis, risk assessment, and financial forecasting. By incorporating the neutrality membership, QNSs can capture situations where elements possess an intermediate or neutral nature, allowing for a more comprehensive understanding of complex phenomena.

In the article [7] Johnson Awolola defined the α-lower level neutrosophic set and α-upper level neutrosophic set. He has consider α-lower level neutrosophic set and α-upper level neutrosophic set as follows:

$L(A,\alpha) = \{x \in X \,|T_A(x) \geq \alpha, I_A(x) \geq \alpha, F_A(x) \leq \alpha\}$ and

$U(A,\alpha) = \{x \in X \,|T_A\ (x) \leq \alpha, I_A(x) \leq \alpha, F_A(x) \geq \alpha\}$.

In this article, we have introduced a notion of α-level sets in Quadripartitioned Neutrosoph Sets and studied different properties applying to real-life problems.

In this article, we have considered the dependent Quadripartitioned Neutrosoph variable. First, we have defined a Quadripartitioned Neutrosoph neutrosophic set and normalized the set so that the sum of all membership values lies between 0 to 1 . In some of the articles authors mostly use four-valued fuzzy logic, which is the generalization of fuzzy logic [8]. We can generalize our concepts by introducing the weight function on the Quadripartitioned Neutrosoph set.

For this work, we have studied various articles in the direction of Quadripartitioned Neutrosophic Sets and neutrosophic sets like medical diagnosis [9], database [10], topology [11], graph theory [12], and decision-making problems [13].

2 PRELIMINARY

In this section, we provide some definitions and results that are very relevant and useful for the preparation of the main results of this article.

Definition 2.1 [6]. Suppose that W is a universe of discourse. Then P, a Neutrosophic Set over W is defined as follows:

$$\mathrm{P} = \{(\mathrm{q}, \mathrm{T_P(q)}, \mathrm{I_P(q)}, \mathrm{F_p(q)}) : \mathrm{q} \in \mathrm{W}\},$$

where $T_P(q), I_P(q), F_P(q) (\in [0,1])$ are the truth membership, indeterminacy membership, and falsity membership values of $q \in W$. $So, 0 \leq T_P(q) + I_P(q) + F_p(q) \leq 3$, for all $q \in W$.

Definition 2.2 [6]. The absolute Neutrosophic Set (1_{N}) and null Neutrosophic Set (0_{N}) over a fixed set W are defined as follows:

$$1.\ 1_{\mathrm{N}} = \{(\mathrm{q}, 1,0,0): \mathrm{q} \in \mathrm{W}\}$$

$$2.\ 0_{\mathrm{N}} = \{(\mathrm{q}, 0,1,1): \mathrm{q} \in \mathrm{W}\}.$$

Definition 2.3 [14] Let Ω be a fixed set. Then, a $SVQNSP$ over Ω is defined as follows:

$$P = \{(q, T_P(q), C_P(q), U_P(q), F_P(q)): q \in \Omega\}$$

where $T_P(q), C_P(q), U_P(q), F_P(q) (\in [0,1])$ are the truth, contradiction, ignorance, and falsity membership values of $q \in \Omega$. So, $0 \leq T_P(q) + C_P(q) + U_P(q) + F_P(q) \leq 4, q \in \Omega$.

In case of normalize qudripartitioned neutrosophic set $0 \leq T_P(q) + C_P(q) + U_P(q) + F_P(q) \leq 1, q \in \Omega$.

Definition 2.4 [15] The absolute $SVQNS(1_{\mathrm{QN}})$ and the null $SVQNS(0_{\mathrm{QN}})$ over Ω are definedas follows:

$$1.\ 1_{QN} = \{(q, 1,1,0,0): q \in \Omega\};$$

$$2.\ 0_{QN} = \{(q, 0,0,1,1): q \in \Omega\}.$$

Remark 2.1 [14] Suppose that R is an SVQNS over a fixed set Ω. Then, $0_{\mathrm{QN}} \subseteq R \subseteq 1_{\mathrm{QN}}$.

Definition 2.5 [14]. Suppose that $X = \{(q, T_X(q), C_X(q), U_X(q), F_X(q)): q \in \Omega\}$ and $Y = \{(q, T_Y(q), C_Y(q), U_Y(q), F_Y(q)): q \in \Omega\}$ be two SVQNSs over Ω. Then, $X \subseteq Y \Leftrightarrow T_X(q) \leq T_Y(q), C_X(q) \leq C_Y(q), U_X(q) \geq U_Y(q), F_X(q) \geq F_Y(q)$, for all $q \in \Omega$.

Definition 2.6 [14] Suppose that $X = \{(q, T_X(q), C_X(q), U_X(q), F_X(q)): q \in \Omega\}$ and $Y = \{(q, T_Y(q), C_Y(q), U_Y(q), F_Y(q)): q \in \Omega\}$ be two SVQNSs over a fixed set Ω. Then, the union of X and Y is defined as follows:
$X \cup Y = \{(q, \max\{T_X(q), T_Y(q)\}, \max\{C_X(q), C_Y(q)\}, \min\{U_X(q), U_X(q)\},$
$\min\{F_X(q), F_X(q)\}): q \in \Omega\}$.

Definition 2.7 [14] Suppose that $X = \{(q, T_X(q), C_X(q), U_X(q), F_X(q)): q \in \Omega\}$ and $Y = \{(q, T_Y(q), C_Y(q), U_Y(q), F_Y(q)): q \in \Omega\}$ be two SVQNSs over Ω. Then, the intersection of X and Y is defined as follows: $X \cap Y = \{(q, \min\{T_X(q), T_Y(q)\},$ $\min\{C_X(q), C_Y(q)\}, \max\{U_X(q), U_X(q)\}, \max\{F_X(q), F_X(q)\}): q \in \Omega\}$.

Definition 2.8 [14] Suppose that $X = \{(q, T_X(q), C_X(q), U_X(q), F_X(q)): q \in \Omega\}$ and $Y = \{(q, T_Y(q), C_Y(q), U_Y(q), F_Y(q)): q \in \Omega\}$ be two SVQNS over Ω. Then, the complement of X is defined as follows:

$$X^c = \{(q, F_X(q), U_X(q), C_X(q), T_X(q)): q \in \Omega\}.$$

Let us consider the following example for the quadripartitioned neutrosophic set.

Example 2.1 Assume that $\Omega = \{a, b, c\}$, three elements of the sets. But we do not have any proper information about all the elements. Suppose for the element a some positive values, some negative values some contradiction, and some unknown information are there. Similarly for other elements respectively. In such cases, quadripartitioned neutrosophic sets are very helpful in representing or dealing with the objects. We called it true membership value,

Contradiction $A = \{(a, \langle 0.3,0.5,0.4,0.5\rangle), (b, \langle 0.5,0.7,0.6,0.4\rangle), (c, \langle 0.7,0.2,0.2\rangle)\}$,
where the degree of goodness of capability is 0.3, degree of contradiction of capability is 0.5 , degree of unknown of capability is 0.4 and degree of the falsity of capability is 0.5 implying $T_A(a) = 0.3, C_A(a) = 0.5, U_A(a) = 0.5, F_A(a) = 0.5$, etc.

For simplicity, $A = \{\langle x, T_A(x), C_A(x), U_A(x), F_A(x)\rangle \mid x \in \Omega\}$, can be expressed as $A(x) = (T_A(x), C_A(x), U_A(x), F_A(x))$ since the membership functions T_A, I_A, F_A are defined from Ω into the unit interval $[0,1]$.

Definition 2.9 [2] Let A and B be two quadripartitioned neutrosophic sets in a non-empty set Ω. Then

1. $A \subseteq B \Leftrightarrow T_A(x) \leq T_B(x), C_A(x) \leq C_B(x), U_A(x) \geq U_B(x), F_A(x) \geq F_B(x)$.
2. $A = B \Leftrightarrow T_A(x) = T_B(x), C_A(x) = C_B(x), U_A(x) = U_B(x), F_A(x) = F_B(x)$.
3. $A \cap B = \{\langle x, \Lambda(T_A(x), T_B(x)), \Lambda(C_A(x), C_B(x)), \vee (U_A(x), U_B(x)), \vee (F_A(x), F_B(x))\rangle \mid x \in X\}$.
4. $A \cup B = \{\langle x, \vee (T_A(x), T_B(x)), \vee (C_A(x), C_B(x)), \Lambda(U_A(x), U_B(x))\Lambda(F_A(x), F_B(x))\rangle \mid x \in X\}$, where Λ and $\vee$ are minimum and maximum operations.
5. $A^c = \{\langle x, F_A(x), U_A(x), C_A(x), T_A(x)\rangle \mid x \in X\}$.
6. $A \setminus B = \{\langle x, T_A(x) \wedge F_B(x), C_A(x) \wedge U_B(x), U_A(x) \vee C_B(x), F_A(x) \vee T_B(x)\rangle \mid x \in X\}$.

With reference to Definition $2.2(v)$, $(A^c)^c = A$.

Remark 2.2 If $\{A_i \mid i \in J\}$ is a family of quadripartitioned neutrosophic sets, then $\left(\cup_{i\in J} A_i\right)^c = \cap_{i\in J} A_i^c$ and $\left(\cap_{i\in J} A_i\right)^c = U_{i\in J} A_i^c$.

Proposition 2.1 Let A, B, C, D be any quadripartitioned neutrosophic sets in a non-empty set X, we have

1. if $A \subseteq B$ and $B \subseteq C$, then $A \subseteq C$.
2. if $A \subseteq B$, then $B^c \subseteq A^c$.
3. if $A \subseteq B$ and $A \subseteq C$, then $A \subseteq B \cap C$.
4. if $A \subseteq B$ and $C \subseteq B$, then $A \cup C \subseteq B$.
5. if $A \subseteq B$ and $C \subseteq D$, then $A \cup C \subseteq B \cup D$ and $A \cap C \subseteq B \cap D$.

3 FOUNDATION OF α-LEVEL QUADRIPARTITIONED NEUTROSOPH SETS

In this section we are going to define α - level quadripartitioned neutrosoph sets and study the various property of it's.

Definition 3.1 Let $A = \{\langle x, T_A(x), C_A(x), U_A(x), F_A(x)\rangle \mid x \in X\}$ be any quadripartitioned neutrosophic set in a non-empty set X. Then for any $\alpha \in [0,1]$, the α - level Quadripartitioned Neutrosoph Sets of A denoted by $Q(A, \alpha)$ defined as follows:

$$Q(A, \alpha) = \{x \in X : T_A(x) + C_A(x) > \alpha, F_A(x) < 1 - \alpha\}$$

Example 3.1 Consider a set of pneumonia patients who have different health problems we will form a neutrosophic set based on the given information and different level of risk for pneumonia.

The symptoms of pneumonia can vary from person to person, but common symptoms can be considered as follows:

Pneumonia, also known as "Nimuniya" in some regions, is an infection that affects the lungs. It can be caused by various pathogens such as bacteria, viruses, or fungi. The symptoms of pneumonia can vary depending on the individual, the cause of the infection, and the severity of the condition. Here are some common symptoms associated with pneumonia:

1. Cough: A persistent cough is a common symptom of pneumonia. It may produce phlegm or mucus, which can be green, yellow, or bloody.
2. Chest pain: You may experience chest pain or discomfort, which can worsen with deep breaths or coughing.
3. Shortness of breath: Difficulty breathing or shortness of breath is a typical symptom of pneumonia. You may feel breathless, especially during physical activity.
4. Fever: A high fever, usually above $38°\mathrm{C}(100.4°\mathrm{F})$, is a common sign of pneumonia. However, not all cases of pneumonia present with a fever.
5. Fatigue: Pneumonia can cause extreme tiredness or fatigue, making it difficult to carry out daily activities.
6. Sweating and chills: Some individuals may experience excessive sweating and chills, especially during fever episodes.
7. Rapid breathing: Shallow and rapid breathing, known as tachypnea, can occur due to the body's attempt to compensate for the impaired lung function.
8. Bluish tint: In severe cases, the lips or nail beds may develop a bluish tint, indicating a lack of oxygen in the blood.
9. Confusion: Elderly individuals or those with weakened immune systems may experience confusion or delirium as a symptom of pneumonia.
10. It's important to note that the symptoms can vary, especially in children and older adults. If you suspect you or someone else may have pneumonia, it is advisable to seek medical attention for an accurate diagnosis and appropriate treatment.

It's important to note that these symptoms can also be caused by other respiratory illnesses, and some individuals infected with pneumonia may experience mild or no symptoms at all.

Let $P = \{P_1, P_2, P_3, \dots, P_8\}$ be the set of patients, $S =$ different symptoms. Where, S_1-Cough, S_2-Chest pain, S_3-Shortness of breath, S_4-Fever, S_5-Fatigue, S_6-Sweating and chills, S_7-Rapid breathing, S_8 - Bluish tint, S_9-Confusion.

We use in the table $CF =$ contradiction or confusion which is the indeterminacy factor which is neither completely Yes nor No., $UN =$ contradiction or confusion which is the indeterminacy factor which is neither completely Yes nor No.

D	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
S_1	YES	YES	YES	NO	CF	CF	UN	UN
S_2	YES	NO	YES	NO	NO	CF	YES	NO
S_3	NO	YES	CF	NO	YES	YES	UN	NO
S_4	NO	NO	NO	YES	NO	NO	YES	NO
S_5	CF	CF	YES	NO	UN	NO	YES	NO
S_6	CF	CF	UN	UN	NO	NO	YES	NO
S_7	UN	CF	YES	CF	YES	NO	YES	CF
S_8	UN	UN	YES	YES	NO	NO	YES	CF
S_9	YES	NO	UN	YES	NO	NO	UN	CF

Table 1. Patients response to several symptoms.

Here the quadripartitioned neutrosophic set based on the above information table is

Let $P = \{(p_1, \langle 0.6,0.4,0.4,0.4\rangle), (p_2, \langle 0.4,0.6,0.2,0.6\rangle), (p_3, \langle 1,0.6,0.4,0.2\rangle), (p_4, \langle 0.6,0.2,0.2,0.8\rangle), (p_5, \langle 0.4,0.2,0.2,0.1\rangle), (p_6, \langle 0.2,0.4,0,0.1\rangle), (p_7, \langle 1,0,0.6,0\rangle), (p_8, \langle 0,0.6,0.2,1\rangle)\}$ and $\alpha \in [0,1]$.

The normalized quadripartitioned neutrosophic set is

$P = \{(p_1, \langle 0.333,0.2222,0.2222,0.22222\rangle), (p_2, \langle 0.2222,0.33333,0.11111,0.33333\rangle), (p_3, \langle 0.4545,0.0.2727,0.1818,0.0909\rangle), (p_4, \langle 0.3333,0.1111,0.1111,0.4444\rangle), (p_5, \langle 0.4444,0.2222,0.2222,0.1111\rangle), (p_6, \langle 0.2857,0.5714,0,0.1429\rangle), (p_7, \langle 0.6250,0,0.375,0\rangle), (p_8, \langle 0,0.3333,0.1111,0.5555\rangle)\}$ and $\alpha \in [0,1]$.

Then for $\alpha = 0$ the corresponding α-level and strong α-level sets are $Q(P,0) = \{p_1, p_2, p_3, p_4, p_5, p_6, p_7, p_8\}$ and $S(P,0) = \{p_1, p_2, p_3, p_4, p_5\}$.

For $\alpha = 0.3$ the corresponding α-level sets is $Q(P,0.3) = \{p_1, p_2, p_3, p_4, p_7, p_8\}$ and $S(P,0.3) = \{p_1, p_2, p_3, p_4, p_5, p_6, p_7, p_8\}$.

For $\alpha = 0.6$ the corresponding α-level set is $Q(P,0.6) = \{p_6, p_7\}$

For $\alpha = 1$ the corresponding α-level set is $Q(P,1) = \emptyset$

From the above example we have the following observations,

1. For $\alpha = 0$ confidence level the level set will contain all the elements of the set A.
2. For $\alpha = 1$ confidence level the level set will be empty set.

If A, B, C are qudripartitioned neutrosophic sets in a non-empty X and $\alpha, \beta \in [0,1]$, then the results in the following proposition are not difficult to verify from definitions.

Proposition 3.1

1. $A \subseteq B \Rightarrow Q(A,\alpha) \subseteq Q(B,\alpha)$.
2. $\alpha > \beta \Rightarrow (A,\alpha) \subseteq (A,\beta)$.
3. $Q(A,\alpha) \cup Q(B,\alpha) \subseteq Q(A \cup B,\alpha)$.
4. $Q(A \cap B,\alpha) \subseteq Q(A,\alpha) \cap Q(B,\alpha)$.
5. $A = B \Leftrightarrow Q(A,\alpha) = Q(B,\alpha), \forall \alpha \in [0,1]$.
6. $\left(\bigcup_{i\in J} A_i, \alpha\right) = \bigcup_{i\in J}(A_i,\alpha)$.
7. $\left(\bigcap_{i\in J} A_i, \alpha\right) = \bigcap_{i\in J}(A_i,\alpha)$.

Proof. 1. Let $x \in Q(A,\alpha) \Longrightarrow T_A(x) + C_A(x) > \alpha, F_A(x) < 1-\alpha$

$\Rightarrow T_B(x) + C_B(x) > \alpha, F_B(x) < 1-\alpha$

[Since, $A \subseteq B \Rightarrow T_A(x) < T_B(x), C_A(x) < C_B(x), U_A(x) > U_B(x), F_A(x) > F_B(x)$]

$\Rightarrow x \in Q(B,\alpha)$

Hence, $A \subseteq B \Rightarrow Q(A,\alpha) \subseteq Q(B,\alpha)$.

2. Let $x \in Q(A,\alpha) \Longrightarrow T_A(x) + C_A(x) > \alpha > \beta, F_A(x) < 1-\alpha < 1-\beta$

$\Rightarrow T_A(x) + C_A(x) > \beta, F_A(x) < 1-\beta$

$\Rightarrow x \in (A,\beta)$

Hence, $\alpha > \beta \Rightarrow Q(A,\alpha) \subseteq Q(A,\beta)$.

3. Let $x \in Q(A,\alpha) \cup Q(B,\alpha)$

$\Rightarrow x \in Q(A,\alpha)$ or $x \in Q(B,\alpha)$

$= \{x \in X: \{T_A(x) + C_A(x) > \alpha, F_A(x) < 1-\alpha\}or\{x \in X: \{T_B(x) + C_B(x) > \alpha, F_B(x) < 1-\alpha\}$

$= \{x \in X: \{\max\{T_A(x), T_B(x)\} + \text{Max}\{C_A(x), C_B(x)\} > \alpha, \min\{F_A(x), F_B(x)\} < 1-\alpha\}$

$= \{x \in X: T_{A\cup B}(x) + C_{A\cup B}(x) > \alpha, F_{A\cup B}(x) < 1-\alpha\}$

$= Q(A \cup B,\alpha)$ Hence, $Q(A,\alpha) \cup Q(B,\alpha) \subseteq Q(A \cup B,\alpha)$

The converse of the theorem is not necessarily true we will see from the following example Consider A and B be two normalize quadripartitioned neutrosophic sets. Where, $A = \{(x, \langle 0.5,0.2,0.1,0.2\rangle), (y, \langle 0.1,0.2,0.5,0.2\rangle)\}$ and $B = \{(x, \langle 0.2,0.5,0.1,0.2\rangle), (y, \langle 0.3,0.2,0.1,0.4\rangle)\}$

$A \cup B = \{(x, \langle 0.5,0.5,0.1,0.2\rangle), (y, \langle 0.3,0.2,0.1,0.2\rangle)\}$

Normalize quadripartitioned neutrosophic set

$A \cup B = \{(x, \langle 0.384,0.384,0.076,0.154\rangle), (y, \langle 0.375,0.25,0.125,0.25\rangle)\}$

Now, for $\alpha = 0.7 Q(A \cup B, \alpha) = \{x\}, Q(A\alpha) \cup Q(B\alpha) = \{\}$. Hence proved the theorem.

4. Let $x \in Q(A \cap B, \alpha) = \{x \in X: T_{A\cap B}(x) + C_{A\cap B}(x) > \alpha, F_{A\cap B}(x) < 1 - \alpha\}$.

$= \{x \in X: \text{Min}\{T_A(x), T_B(x)\} + \text{Min}\{C_A(x), C_B(x)\} > \alpha, \text{Max}\{F_A(x), F_B(x)\} < 1 - \alpha\}$.

$\Rightarrow \{x \in X: \{T_A(x) + C_A(x)\} > \alpha$ and $\{T_B(x) + C_B(x)\} > \alpha, \{F_A(x) < 1 - \alpha \; and \; F_B(x)\} < 1 - \alpha\}$.

$= \{x \in X: \{T_A(x) + C_A(x)\} > \alpha, F_A(x) < 1 - \alpha\}$ and $\{T_B(x) + C_B(x)\} > \alpha, F_B(x)\} < 1 - \alpha\}$.

$= Q(A, \alpha) \cap Q(B, \alpha)$

Hence, $Q(A \cap B, \alpha) \subseteq Q(A, \alpha) \cap Q(B, \alpha)$.

The converse of the theorem is not necessarily true we will see from the following example Consider A and B be two normalize quadripartitioned neutrosophic sets. Where, $A = \{(x, \langle 0.3,0.2,0.5,0\rangle), (y, \langle 0.3,0.2,0.3,0.2\rangle)\}$ and $B = \{(x, \langle 0.1,0.4,0.1,0.4\rangle), (y, \langle 0.3,0.2,0.1,0.4\rangle)\}$

$A \cap B = \{(x, \langle 0.1,0.2,0.5,0.4\rangle), (y, \langle 0.3,0.2,0.3,0.4\rangle)\}$

Normalize quadripartitioned neutrosophic set

$A \cap B = \{(x, \langle 0.083,0.167,0.417,0.333\rangle), (y, \langle 0.25,0.17,0.25,0.33\rangle)\}$

Now, for $\alpha = 0.4 Q(A \cap B, \alpha) = \{\}, Q(A\alpha) \cap Q(B\alpha) = \{x\}$. Hence proved the theorem.

5. Clearly, $A = B \Longrightarrow T_A(x) = T_B(x), C_A(x) = C_B(x), F_A(x) = F_B(x) \forall x \in X$.

Undoubtedly, $Q(A, \alpha) = \{x \in X: T_A(x) + C_A(x) > \alpha, F_A(x) < 1 - \alpha\}$

$= \{x \in X: T_B(x) + C_B(x) > \alpha, F_B(x) < 1 - \alpha\}$. Since, $A = B = Q(B, \alpha)$

For the converse part of the theorem, Let us consider $\forall \alpha \in [0,1] Q(A, \alpha) = Q(B, \alpha)$ but not $A \neq B$

Suppose, $y \in A$ such that $y \notin B$.

So, there exist an $\alpha \in [0,1]$ for which $y \in Q(A, \alpha)$. But, $y \notin B$ implies $y \notin Q(B, \alpha)$ for any $\alpha \in [0,1]$.

This is a contradiction to the fact that $Q(A, \alpha) = Q(B, \alpha)$.

6. Let $x \in \bigcup_{i\in\Lambda} Q(A_i, \alpha)$

$\Rightarrow x \in \vee i \in \Lambda Q(A_i, \alpha)$

$= \{x \in X: \vee i \in \Lambda \{T_{A_i}(x) + C_{A_i}(x) > \alpha, \wedge i \in \Lambda F_{A_i}(x) < 1 - \alpha\}$

$= \{x \in X: \{\max\{T_{A_i}(x)\} + \text{Max}\{C_{A_i}(x)\} > \alpha, \min\{F_{A_i}(x), \} < 1 - \alpha\}$

$= \{x \in X: T_{\cup_{i\in\Lambda} A_i}(x) + C_{\cup_{i\in\Lambda} A_i}(x) > \alpha, F_{\cup_{i\in\Lambda} A_i}(x) < 1 - \alpha\}$

$= Q(\bigcup_{i\in\Lambda} A_i, \alpha)$

Hence, $\bigcup_{i\in\Lambda} Q(A_i, \alpha) \subseteq Q(\bigcup_{i\in\Lambda} A_i, \alpha)$

7. Let $x \in Q(\bigcap_{i\in\Lambda} A_i, \alpha) = \{x \in X: T_{A\cap B}(x) + C_{A\cap B}(x) > \alpha, F_{A\cap B}(x) < 1 - \alpha\}$.

$= \{x \in X: T_{\cap_{i\in\Lambda} A_i}(x) + C_{\cap_{i\in\Lambda} A_i}(x) > \alpha, F_{\cap_{i\in\Lambda} A_i}(x) < 1 - \alpha\}$

$\Rightarrow \{x \in X: \{\text{Min}\{T_{A_i}(x)\} + \text{Min}\{C_{A_i}(x)\} > \alpha, \text{Max}\{F_{A_i}(x), \} < 1 - \alpha\}$

$$= \{x \in X: \wedge i \in \Lambda\{T_{A_i}(x) + C_{A_i}(x) > \alpha, \vee i \in \Lambda F_{A_i}(x) < 1 - \alpha\}$$

$= \bigcap_{i\in\Lambda} Q(A_i, \alpha)$.

$Q(\bigcap_{i\in\Lambda} A_i, \alpha) \subseteq \bigcap_{i\in\Lambda} Q(A_i, \alpha)$. Hence the theorem.

Proposition 3.2 For a Quadripartitioned Neutrosoph Sets A, $Q(A, \alpha) \subseteq Q(A, \beta), \forall \alpha, \beta \in$ [0,1] with $\alpha > \beta$.

Proof: Let $x \in (A, \alpha) \Rightarrow T_A(x) + C_A(x) > \alpha, F_A(x) < 1 - \alpha \Rightarrow T_A(x) + C_A(x) > \beta, F_A(x) < 1 - \beta$

$\Rightarrow x \in Q(A, \beta)$

Hence, $Q(A, \alpha) \subseteq Q(A, \beta), \forall \alpha, \beta \in [0,1]$.

Proposition 3.3 The distributive laws are satisfied for α-lower level qudripartitioned neutrosophic set.

$Q(A \cup B, \alpha) \cap Q(A \cup C, \alpha) \subseteq Q(A \cup (B \cap C), \alpha)$.

$Q(A \cap B, \alpha) \cup Q(A \cap C, \alpha) \subseteq Q(A \cap (B \cup C), \alpha)$.

Proof: Similar to the proof of Proposition 3.1 & 3.2.

4 APPLICATION OF α-LEVEL QUADRIPARTITIONED NEUTROSOPH SET IN DECISION MAKING AND ITS ALGORITHM

Consider a situation where 5 members ($\mathbf{I}_1, \mathbf{I}_2, \mathbf{I}_3, \mathbf{I}_4$ and $\mathbf{I}_5$) of the interview panel give marks for both suitability and non-suitability of a candidate for a specific job role in a normalized scale of one. It is evident to mention that the sum of marks (say s) obtained by a student from an interviewer for suitability and non-suitability must not be more than 1 but could be less or equal to one. If the sum (s) is less than 1, then it means that the interviewer is not sure whether the candidate can perform (1-s)-portion of the job role or not. Suppose there are 10 candidates ($\mathbf{C}_1, \mathbf{C}_2, \mathbf{C}_3, \mathbf{C}_4, \mathbf{C}_5, \mathbf{C}_6, \mathbf{C}_7, \mathbf{C}_8, \mathbf{C}_9$ and $\mathbf{C}_{10}$) who got the following marks from the interviewers:

Suitability	$\mathbf{C}_1$	$\mathbf{C}_2$	$\mathbf{C}_3$	$\mathbf{C}_4$	$\mathbf{C}_5$	$\mathbf{C}_6$	$\mathbf{C}_7$	$\mathbf{C}_8$	$\mathbf{C}_9$	$\mathbf{C}_{10}$
$\mathbf{I}_1$	0.35	0.70	0.38	0.37	0.60	0.71	0.21	0.58	0.50	0.35
$\mathbf{I}_2$	0.71	0.80	0.49	0.60	0.57	0.72	0.31	0.52	0.30	0.45
$\mathbf{I}_3$	0.48	0.60	0.57	0.75	0.63	0.56	0.25	0.60	0.40	0.21
$\mathbf{I}_4$	0.81	0.70	0.31	0.45	0.83	0.67	0.31	0.48	0.37	0.38
$\mathbf{I}_5$	0.90	0.80	0.60	0.71	0.73	0.72	0.19	0.49	0.20	0.37

Table 2. Suitability of several candidates as per several interviewer

Non-suitability	$\mathbf{C}_1$	$\mathbf{C}_2$	$\mathbf{C}_3$	$\mathbf{C}_4$	$\mathbf{C}_5$	$\mathbf{C}_6$	$\mathbf{C}_7$	$\mathbf{C}_8$	$\mathbf{C}_9$	$\mathbf{C}_{10}$
$\mathbf{I}_1$	0.15	0.14	0.18	0.11	0.35	0.01	0.41	0.38	0.20	0.55
$\mathbf{I}_2$	0.15	0.03	0.19	0.07	0.21	0.07	0.53	0.32	0.15	0.45
$\mathbf{I}_3$	0.17	0.11	0.17	0.07	0.25	0.06	0.35	0.30	0.19	0.31
$\mathbf{I}_4$	0.10	0.09	0.11	0.15	0.11	0.07	0.41	0.34	0.21	0.58
$\mathbf{I}_5$	0.10	0.08	0.16	0.11	0.20	0.02	0.39	0.29	0.25	0.47

Table 3. Non-suitability of several candidates as per several interviewer

If we take the minimum of the marks obtained by a candidate from all interviewers for suitability, then this minimum value (**m**) interprets that there is no confusion among the interviewers that the candidate can perform m-portion of the job role. So we take **m** to be the membership value for that specific candidate.

Membership Values	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$	$\mathbf{C_{10}}$
m	0.35	0.60	0.31	0.37	0.57	0.56	0.19	0.48	0.20	0.21

Table 4. Membership values for several candidates

If we take the minimum of the marks obtained by a candidate from all interviewers for non-suitability, then this minimum value (n) interprets that there is no confusion among the interviewers that the candidate cannot perform **n**-portion of the job role. So we take **n** to be the non-membership value for that specific candidate.

Non-Membership Values	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$	$\mathbf{C_{10}}$
n	0.10	0.03	0.11	0.07	0.11	0.01	0.35	0.29	0.15	0.31

Table 5. Non-Membership values for several candidates

If the maximum of the marks obtained by a candidate from all interviewers for the suitability is $\mathbf{m}'$, then interviewers contradict among themselves about the suitability of the candidate for ($\mathbf{m}' - \mathbf{m}$)-portion of the job role. If the maximum of the marks obtained by a candidate from all interviewers for the non-suitability is $\mathbf{n}'$, then interviewers contradict among themselves about the non-suitability of the candidate for $(\mathbf{n}' - \mathbf{n})$-portion of the job role. If the total contradiction is **c**, then $(\mathbf{m} + \mathbf{n} + \mathbf{c})$ must not exceed 1. Thus we take,

$$\text{Contradiction } (c) = \begin{cases} (m' - m) + (n' - n) \text{ if } m' + n' \leq 1 \\ 1 - m - n \text{ if } m' + n' > 1 \end{cases}$$

Contradiction	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$	$\mathbf{C_{10}}$
c	0.55	0.31	0.37	0.46	0.32	0.22	0.30	0.21	0.40	0.48

Table 6. Contradiction values for several candidates

Now, if $(\mathbf{m} + \mathbf{c} + \mathbf{n}) = \mathbf{1}$, is clear that the candidate has been fully assessed, but if $(\mathbf{m} + \mathbf{c} + \mathbf{n}) < \mathbf{1}$, then the candidate has not been clearly assessed. None of the interviewers comments about $(\mathbf{1} - (\mathbf{m} + \mathbf{c} + \mathbf{n}))$ - portion of the job role for that specific candidate. So we take the unknown $(\mathbf{u} = \mathbf{1} - (\mathbf{m} + \mathbf{c} + \mathbf{n}))$.

Unknown	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$	$\mathbf{C_{10}}$
u	0.00	0.06	0.21	0.10	0.00	0.21	0.16	0.02	0.25	0.00

Table 7. Unknown values for several candidates

The total quadripartition neutrosophic set H is given by

$H = \{\langle C1, 0.35, 0.55, 0.00, 0.10\rangle, \langle C2, 0.60, 0.31, 0.06, 0.03\rangle, \langle C3, 0.31, 0.37, 0.21, 0.11\rangle, \langle C4, 0.37, 0.46, 0.10, 0.07\rangle, \langle C5, 0.57, 0.32, 0.00, 0.11\rangle, \langle C6, 0.56, 0.22, 0.21, 0.01\rangle,$

$\langle C7, 0.19, 0.30, 0.16, 0.35\rangle$, $\langle C8, 0.48, 0.21, 0.02, 0.29\rangle$, $\langle C9, 0.20, 0.40, 0.25, 0.15\rangle$, $\langle C10, 0.21, 0.48, 0.00, 0.31\rangle\}$.

Thus we have membership, contradiction, unknown, and non-membership values for each candidate. And we are ready to apply the α - level cut for the selection of the candidates. Let m_i, c_i, u_i and n_i be the membership, contradiction, unknown, and non-membership values for the i-th candidate candidate C_i.

Suppose the company has fixed criteria that a candidate must participate in at least 90% of the evaluation process i.e. u_i must be less than or equal to 0.1. For a specific value of α, if $u_i \leq 0.1, m_i + c_i > \alpha$ and $n_i < 1 - \alpha$, then the candidate C_i get selected for the job. But, $m_i + c_i > \alpha \Longrightarrow 1 - m_i - c_i < 1 - \alpha$. Thus for a specific value of α, if $u_i \leq 0.1, 1 - m_i - c_i < 1 - \alpha$. and $n_i < 1 - \alpha$, the candidate C_i get selected for the job. Now we take, $x_i = 1 - m_i - c_i, y_i = n_i$ and $z = u_i$.

$\mathbf{C}_i$	$\mathbf{C}_1$	$\mathbf{C}_2$	$\mathbf{C}_3$	$\mathbf{C}_4$	$\mathbf{C}_5$	$\mathbf{C}_6$	$\mathbf{C}_7$	$\mathbf{C}_8$	$\mathbf{C}_9$	$\mathbf{C}_{10}$
x_i	0.10	0.09	0.32	0.17	0.11	0.22	0.51	0.31	0.40	0.31
y_i	0.10	0.03	0.11	0.07	0.11	0.01	0.35	0.29	0.15	0.31
z_i	0.10	0.03	0.11	0.07	0.11	0.01	0.35	0.29	0.15	0.31

Table 8. Co-ordinate position for several candidates

In the graphical representation, a candidate's position is above plane $z = 0.1$, implying that the candidate has not completed the evaluation process. So these candidates must not be selected in any situation.

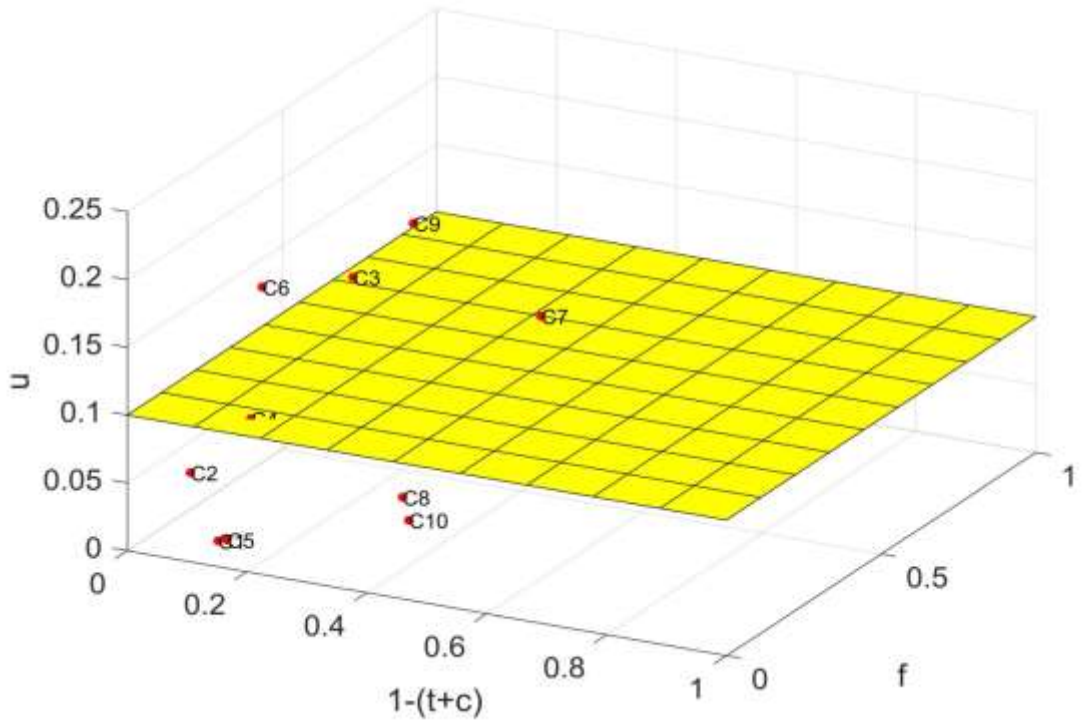

Figure 1. Co-ordinate position for several candidates

So it is clear that 6 candidates $(C_1, C_2, C_4, C_5, C_8, C_{10})$ has completed theevaluation process whereas 4 candidates (C_3, C_6, C_7, C_9) has not completed the evaluation process.

Thus the α-cut represents the interior of a cuboid with a square base for whom the origin is a vertex, three sides are along coordinate axes and each side of the base has a length $(1-\alpha)$ and fixed height 0.1 . If a candidate (x_i, y_i, z_i) lies inside the square, then the candidate C_i gets selected.

If the value of α increases, then the square base shrinks, and hence less number of candidates are selected. If the value of α decreases, then the square base expands and hence more candidates get selected. So we have to select the value of α as per the requirement. For different requirements, α will have different ranges which can be found by using programming. In our research, we have used MATLAB programming (Appendix-I) to find the rage of α, and the results are shown below.

Case-I (Vacancy=0)

We have to fix a very high cut-off so that no candidate gets selected. The range of alpha is $0.910000 < \alpha \leq 1.000000$. For a specific value of $\alpha = 0.9550$. No candidate was selected.

Output :

>> [A] = decpent(M, N, O)

4 students have not completed the evaluation process and 6 students have completed the evaluation process range of alpha is 0.910000 < alpha <= 1.000000

We choose alpha = 0.955000

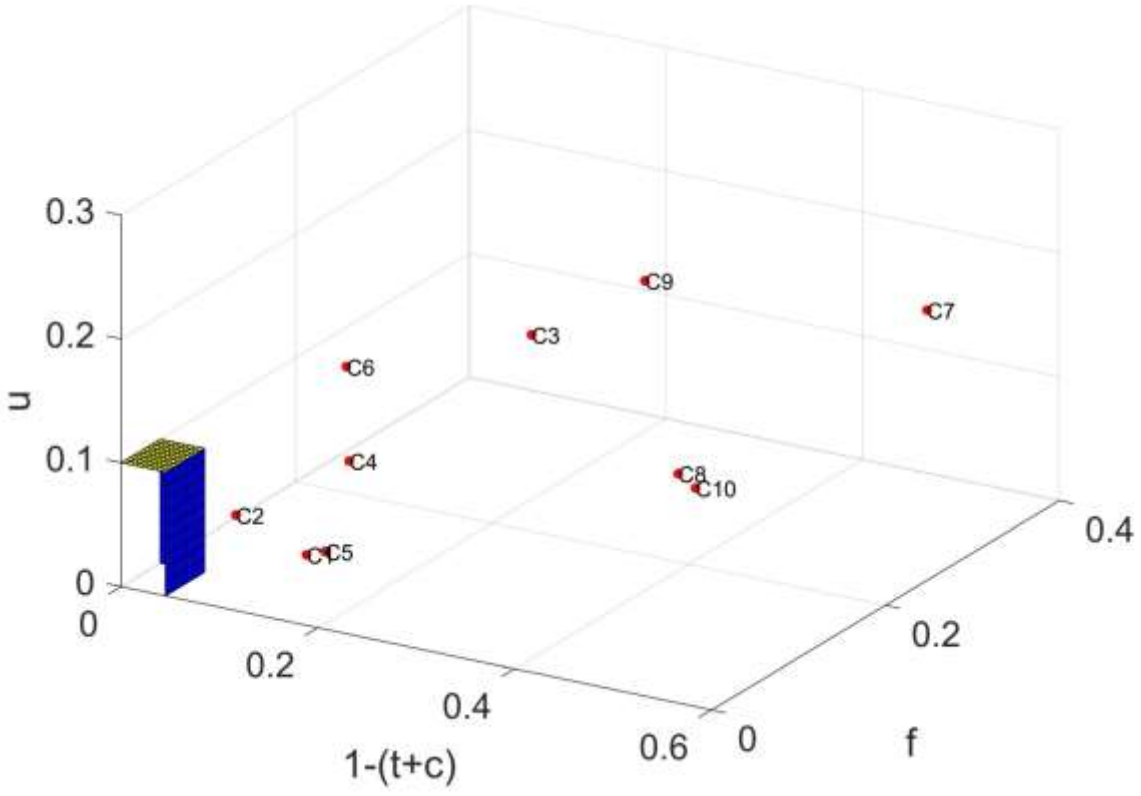

Figure 2. Cut offs to be taken when there is no vacancy.

Case-II (Vacancy=1)
Range of α is $0.900000 < \alpha \leq 0.910000$. For specific value of $\alpha = 0.905000$, selected candidate is C_2.
Output :
>> decpent(M, N, 1)
4 students have not completed the evaluation process and 6 students have completed the evaluation process
range of alpha is 0.900000 < alpha <= 0.910000
We choose alpha = 0.905000
The candidate C[2] is selected>>

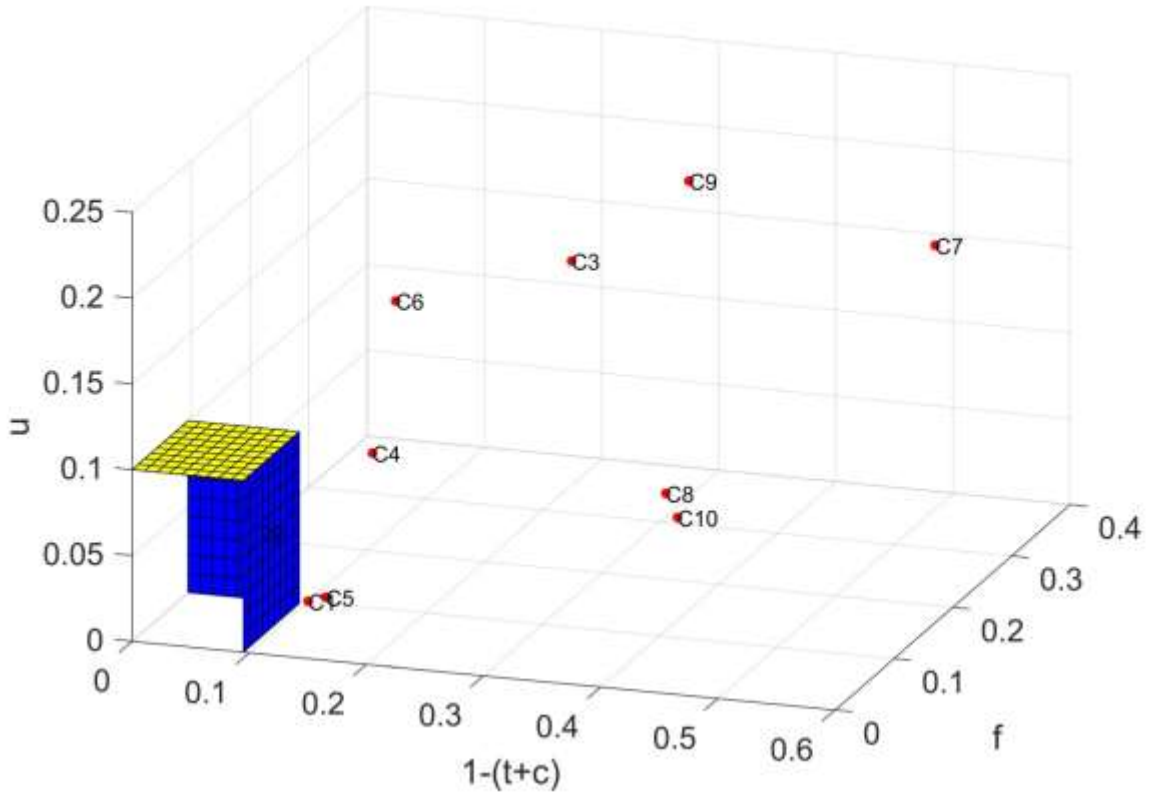

Figure 3. Cut offs to be taken when there is only one vacancy.

Case-III (Vacancy=2)
Range of α is $0.890000 < \alpha \leq 0.900000$. For specific value of $\alpha = 0.895000$, selected candidates are C_1 and C_2.

Output :
>> decpent(M, N, 2)
4 students have not completed the evaluation process and 6 students have completed the evaluation process

range of alpha is 0.890000 < alpha <= 0.900000
We choose alpha = 0.895000
The candidate C[1] is selected
The candidate C[2] is selected>>

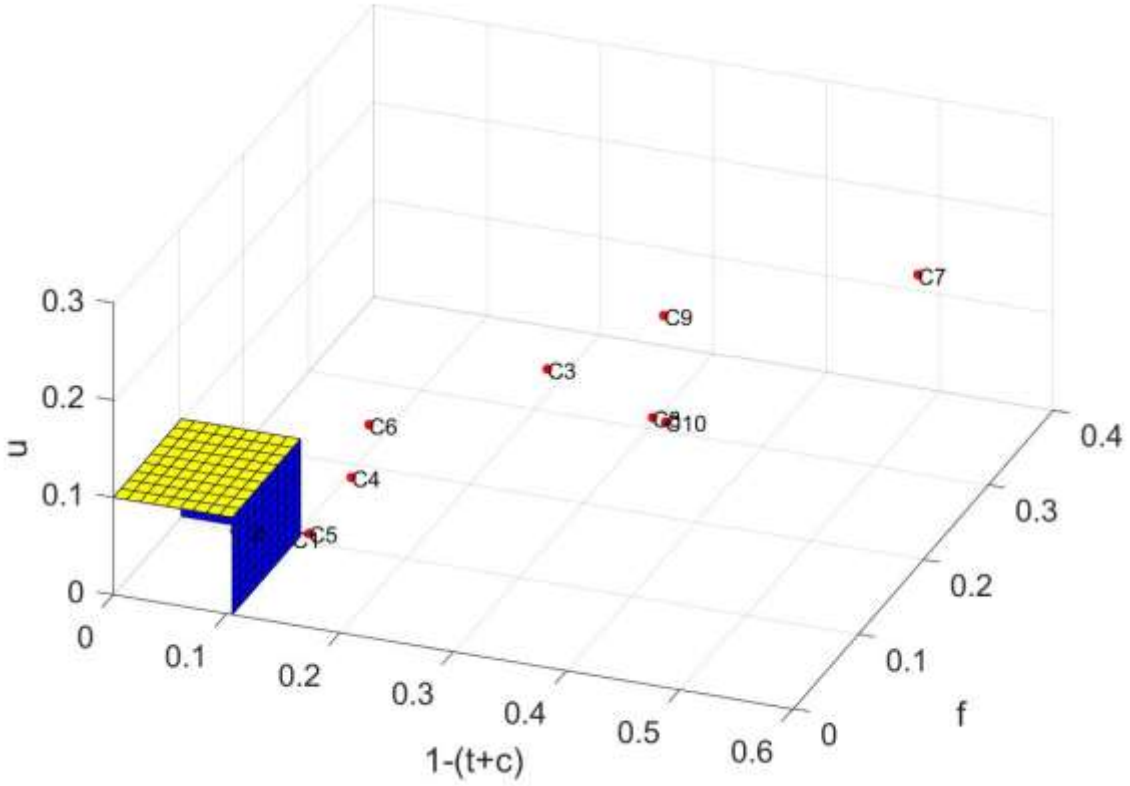

Figure 4. Cut offs to be taken when there are two vacancies.

Case-IV (Vacancy=3)
Range of α is $0.830000 < \alpha \leq 0.890000$. For specific value of $\alpha = 0.860000$, selected candidates are C_1, C_2 and C_5.
Output :

>> decpent(M, N, 3)
4 students have not completed the evaluation process and 6 students have completed the evaluation process
range of alpha is 0.830000 < alpha <= 0.890000
We choose alpha = 0.860000
The candidate C[1] is selected
The candidate C[2] is selected
The candidate C[5] is selected>>

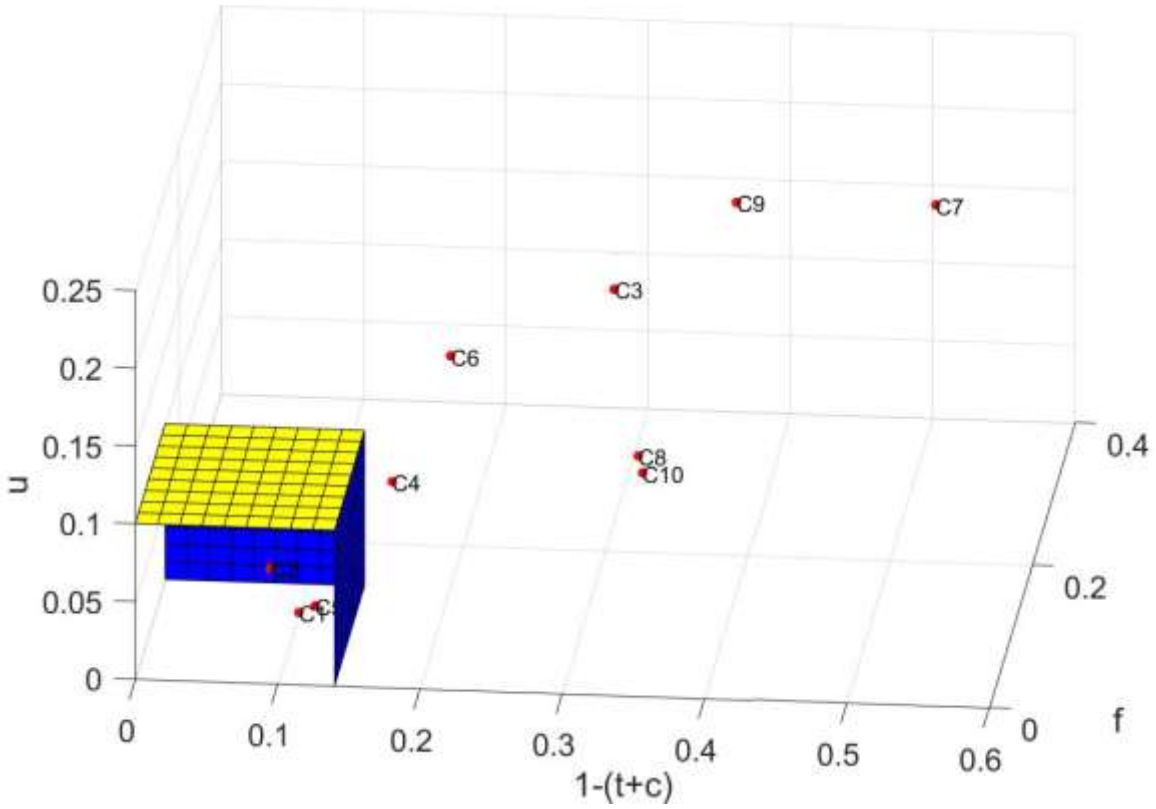

Figure 5. Cut offs to be taken when there are three vacancies.

Case-V (Vacancy=4)

Range of α is $0.690000 < \alpha \leq 0.830000$. For specific value of $\alpha = 0.760000$, selected candidates are C_1, C_2, C_4 and C_5.

Output :

>> decpent(M, N, 4)
4 students have not completed the evaluation process and 6 students have completed the evaluation process
range of alpha is 0.690000 < alpha <= 0.830000
We choose alpha = 0.760000
The candidate C[1] is selected
The candidate C[2] is selected
The candidate C[4] is selected
The candidate C[5] is selected>>

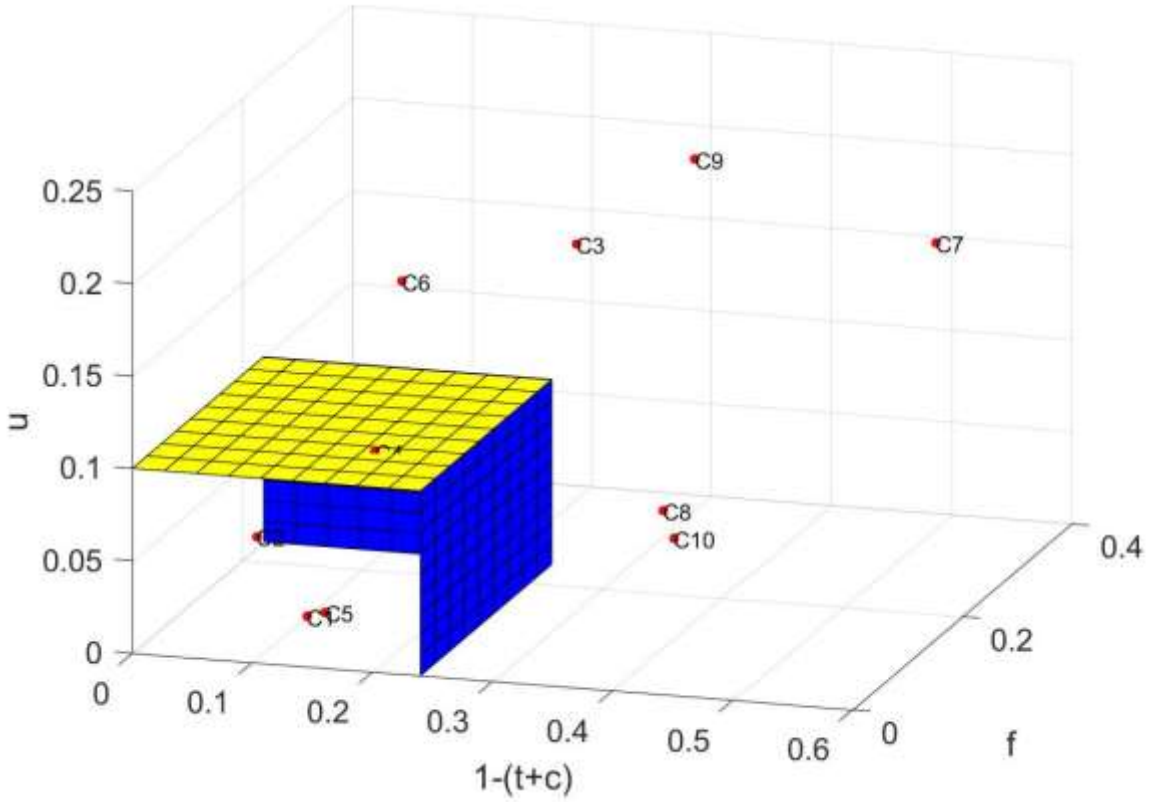

Figure 6. Cut offs to be taken when there are four vacancies.

Case-VI (Vacancy=5)

Range of α is $0.690000 < \alpha \leq 0.690000$. For specific value of $\alpha = 0.690000$, selected candidates are C_1, C_2, C_4, C_5, C_8 and C_{10}.

Output :

>> decpent(M, N, 5)
4 students have not completed the evaluation process and 6 students have completed the evaluation process
range of alpha is 0.690000 < alpha <= 0.690000
We choose alpha = 0.690000
The candidate C[1] is selected
The candidate C[2] is selected
The candidate C[4] is selected
The candidate C[5] is selected
The candidate C[8] is selected
The candidate C[10] is selected>>

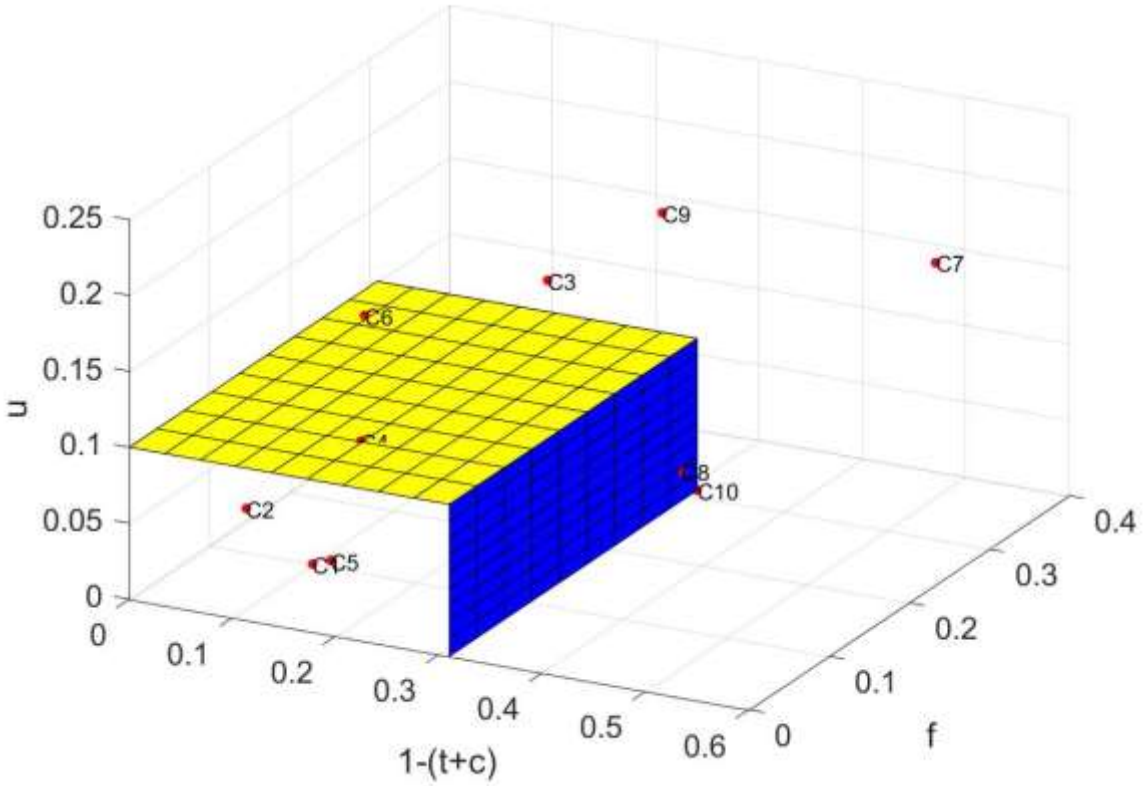

Figure 7. Cut offs to be taken when there are five vacancies.

Further investigation is required because for every possible value of α, C_8 and C_{10} will enter the α-level set together or will leave the α-level sets together.

So, C_8 and C_{10} must me selected or rejected simultaneously and hence selecting 5 candidates is not possible. While decreasing the value of α, C_8 and $C_1 0$ leaves the α-cut for the first time when $\alpha = 0.6900$.

Case-VII (Vacancy=6)

Range of α is $0.000000 < \alpha \leq 0.690000$. For specific value of $\alpha = 0.345000$, selected candidates are C_1, C_2, C_4, C_5, C_8 and C_{10}..

Output :

>> decpent(M, N, 6)
4 students have not completed the evaluation process and 6 students have completed the evaluation process
range of alpha is 0.000000 < alpha <= 0.690000
We choose alpha = 0.345000
The candidate C[1] is selected
The candidate C[2] is selected
The candidate C[4] is selected
The candidate C[5] is selected
The candidate C[8] is selected
The candidate C[10] is selected>>

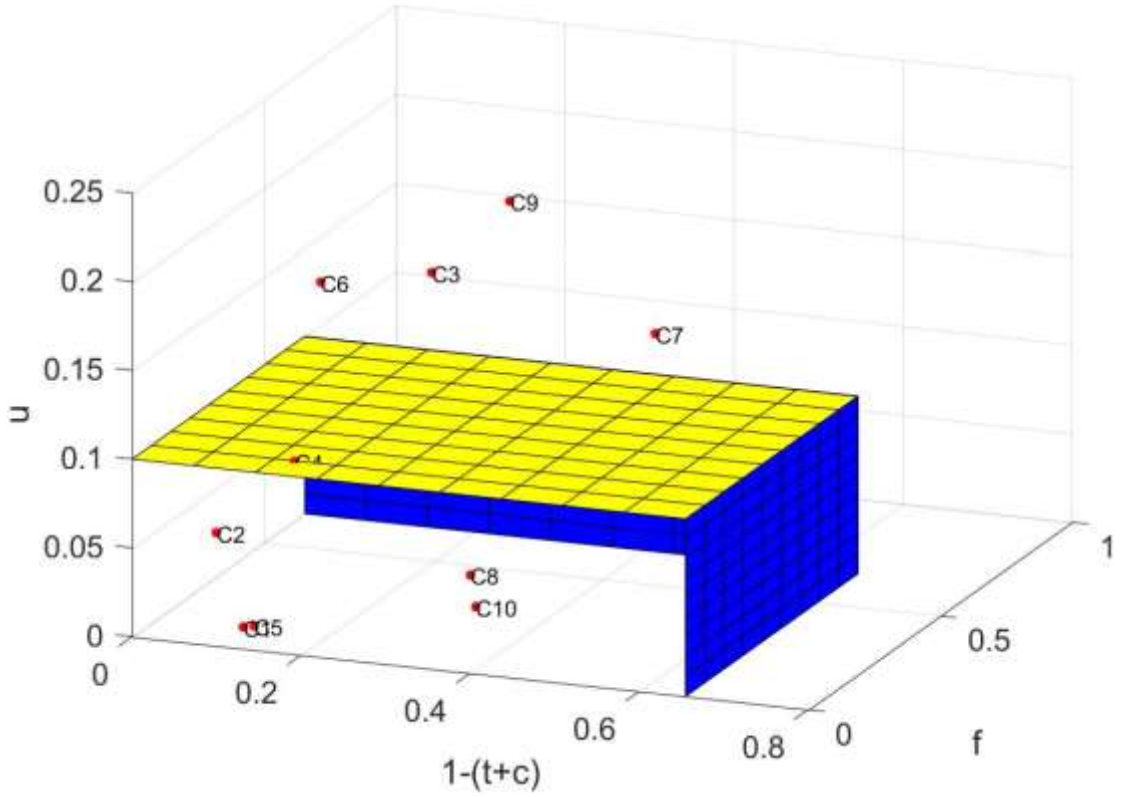

Figure 8. Cut offs to be taken when there are six vacancies.

Case-VIII (Vacancy=7 or more)

Since only 6 candidates has completed the whole evaluation process, such selection is not posible.

Output : >> decpent(M, N, 7)

4 students have not completed the evaluation process and 6 students have completed the evaluation process less than 7 candidates has completed the evaluation process

A totality of results

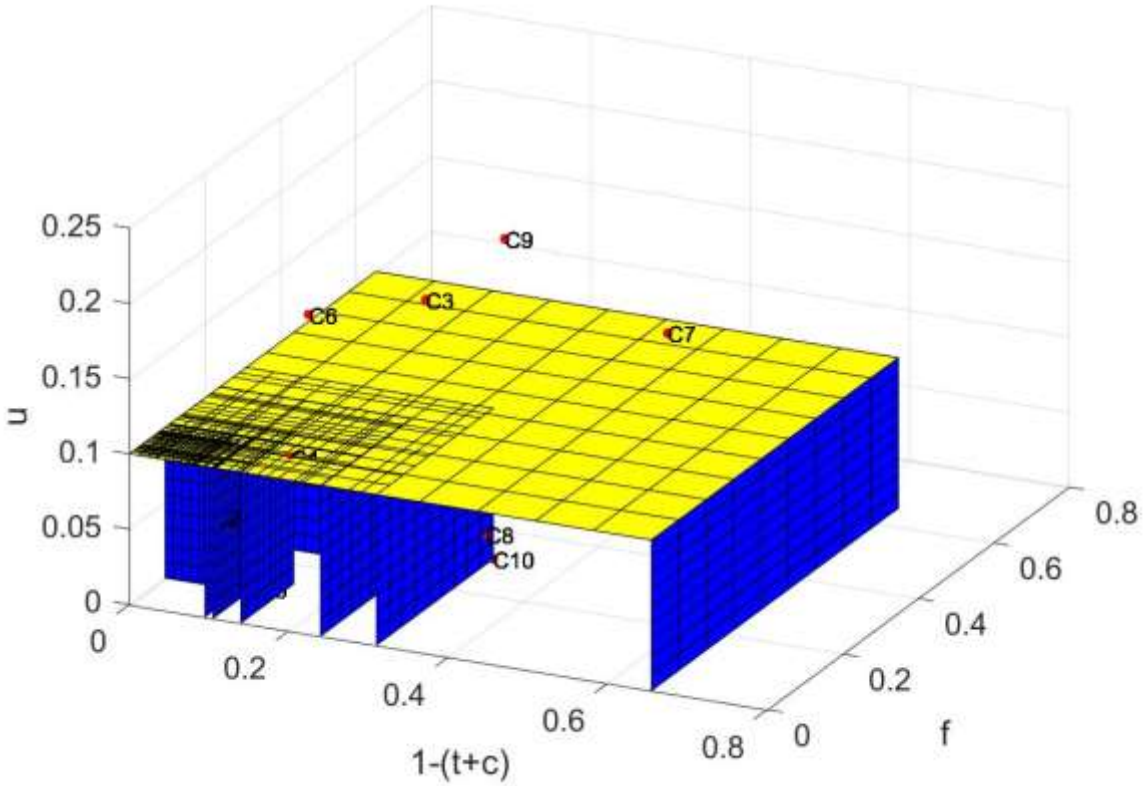

Figure 9. Cut offs to be taken when there are six vacancies.

5 CONCLUSION

Quadripartitioned Neutrosoph Set extends the concept of a neutrosophic set by introducing a neutrality membership component. It provides a powerful mathematical tool for modeling and reasoning with uncertain and contradictory information, enabling a more nuanced analysis in various practical applications.

Now a day in human life scientific results are giving us various opportunity with thatconfusion also comes. Hopefully This paper will help us to overcome confusion and ambiguities. Alpha level Quadripartitioned Neutrosoph sets provide a more flexible and realistic way of modeling uncertain information, as they allow for a more precise description of the degrees of uncertainty and ambiguity involved in decision-making. We can easily Handel the large number of ambiguities or uncertain data through the math-lab programming.

Conflict of Interest: The authors declare that they have no conflict of interest.

Authors Contribution: All the authors have equal contributions to the preparation of this article.

Data Availability: The authors declare that no primary data has been used or generated in this article.

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6 APPENDIX

(Programming)

```
function [ ] = decpent( M,N,vac )
[m,n]=size(M);
max_M=max(M);
min_M=min(M);
max_N=max(N);
```

```
min_N=min(N);
T=min(M);
F=min(N);
for i=1:n
if (max_M(i)+max_N(i)) < 1
C(i)= (max_M(i)+max_N(i))-(min_M(i)+min_N(i));
else
C(i)=1-(min_M(i)+min_N(i));
end
end
for i=1:n
U(i)=1-(min_M(i)+min_N(i)+C(i));
end
x=ones(1,n)-(T+C);
y=F;
z=U;
A=[x;y;z];
j=[];
for i=1:n
if z(i)<=0.1
j=[j,i];
end
end
[m3,n3]=size(j);
m3=n-n3;
fprintf('%d students have not completed the evaluation process and %d students have
completed the evaluation process',m3,n3);
r=[];
for i=1:n3
r(j(i))=max(x(j(i)),y(j(i)));
end
r=sort(r);
rrange=[0,r(m3+1:n),1];
alpharange=1-rrange;
for i=1:n3+1
alpha(i)=((alpharange(i)+alpharange(i+1))/2);
end
if vac>n3
fprintf('\n less than %d candidates has completed the evaluation process',vac);
else
fprintf('\n range of alpha is %f < alpha <= %f',alpharange(vac+2),alpharange(vac+1));
fprintf('\n We choose alpha= %f',alpha(vac+1));
for i=1:n
if x(i)<=(1-alpha(vac+1)) && y(i)<=(1-alpha(vac+1)) && z(i)<=0.1
fprintf('\n The candidate C[%d] is selected',i);
end
```

```
end
labels={'C1','C2','C3','C4','C5','C6','C7','C8','C9','C10'};
plot3(x,y,z,'.','color','r','MarkerSize',15);
text(x,y,z,labels);
r=[r,1];
hold on
[a,b]=meshgrid(linspace(0,(r(m3+vac)+r(m3+vac+1))/2,10),linspace(0,(r(m3+vac)+r
(m3+vac+1))/2,10));
x1=a;
y1=b;
[m1,n1]=size(x1);
[m2,n2]=size(y1);
z1=.1*ones(n1,n2);
surf(x1,y1,z1,'facecolor','y');
hold on;
[a,b]=meshgrid(linspace(0,(r(m3+vac)+r(m3+vac+1))/2,10),linspace(0,.1,10));
x1=a;
z1=b;
[m1,n1]=size(x1);
[m2,n2]=size(y1);
y1=((r(m3+vac)+r(m3+vac+1))/2)*ones(n1,n2);
surf(x1,y1,z1,'facecolor','b');
hold on;
surf(y1,x1,z1,'facecolor','b');
hold on;
legend('candidates','surface');
xlabel('1-(True membership + Contradiction)','FontSize',15);
ylabel('False Membership','FontSize',15);
zlabel('Unknown','FontSize',15);
title('Quadripartitioned Neutrosoph (alpha,0.1)-Cut');
grid on
end
end
```

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